

REMARKS/ARGUMENTS

The Office Action mailed May 14, 2008, has been received and reviewed. Claims 1 through 6, 9 through 15, and 64 through 66 are currently pending in the application. Claims 1 through 6, 9 through 15, and 64 through 66 stand rejected. Applicant has amended claims 1, 64 and 66, and respectfully requests reconsideration of the application as amended herein. The amendments to claims 1 and 66 are supported at least by page 5, lines 24 through 26 of the as-filed specification. Claim 64 has been amended to correct claim dependency. No new matter has been added.

35 U.S.C. § 103(a) Obviousness Rejections

Obviousness Rejection Based on U.S. Patent No. 5,926,736 to deSilva in View of U.S. Patent No. 5,990,556 to Mizobuchi et al. and U.S. Patent No. 5,420,072 to Fiordalice et al.

Claims 1 through 4, 6, 9 through 14 and 64 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over deSilva (U.S. Patent No. 5,926,736) in view of Mizobuchi et al. (U.S. Patent No. 5,990,556) and Fiordalice et al. (U.S. Patent No. 5,420,072). Applicant respectfully traverses this rejection, as hereinafter set forth.

To establish a *prima facie* case of obviousness the prior art reference (or references when combined) must teach or suggest all the claim limitations. *In re Royka*, 490 F.2d 981, 985 (CCPA 1974); *see also* MPEP § 2143.03. Additionally, the Examiner must determine whether there is “an apparent reason to combine the known elements in the fashion claimed by the patent at issue.” *KSR Int’l Co. v. Teleflex Inc.*, 127 S. Ct. 1727, 1740-1741, 167 L.Ed.2d 705, 75 USLW 4289, 82 U.S.P.Q.2d 1385 (2007). Further, rejections on obviousness grounds “cannot be sustained by mere conclusory statements; instead, there must be some articulated reasoning with some rational underpinning to support the legal conclusion of obviousness.” *Id* at 1741, quoting *In re Kahn*, 441, F.3d 977, 988 (Fed. Cir. 2006). To establish a *prima facie* case of obviousness there must be a reasonable expectation of success. *In re Merck & Co., Inc.*, 800 F.2d 1091, 1097 (Fed. Cir. 1986). Furthermore, the reason that would have prompted the combination and the reasonable expectation of success must be found in the prior art, common knowledge, or the nature of the problem itself, and not based on the Applicant’s disclosure. *DyStar Textilfarben GmbH & Co. Deutschland KG v. C. H. Patrick Co.*, 464 F.3d 1356, 1367 (Fed. Cir. 2006);

MPEP § 2144. Underlying the obvious determination is the fact that statutorily prohibited hindsight cannot be used. *KSR*, 127 S.Ct. at 1742; *DyStar*, 464 F.3d at 1367.

deSilva teaches forming an interconnect structure by forming one or more holes within a insulating layer on a substrate, forming a barrier layer over the holes, placing the structure in a vacuum chamber, and depositing and forming an aluminum layer over the barrier layer. deSilva at FIGs. 1 through 5 and column 2, line 30 through column 3, line 67. An antireflective coating is formed on the aluminum layer. *Id.* The structure is subsequently heated to melt the aluminum layer, allowing aluminum to fill in the holes within the insulating layer. *Id.*

Mizobuchi teaches forming an interconnect structure by forming an opening within a dielectric material, depositing a first layer of titanium tungsten over the dielectric material, depositing a second layer of tungsten over the first layer, and depositing an aluminum layer overlying the second layer. Mizobuchi at FIGs. 26 through 29, and 31 through 32, column 7, lines 39 through 46. An antireflective coating on is formed on the aluminum layer. Mizobuchi at column 12, lines 17 through 18.

Fiordalice teaches forming an interconnect structure by forming an opening within a dielectric material, depositing a first layer of titanium nitride over the dielectric material, depositing a second layer of titanium nitride over the first layer, and forming a conductive layer overlying the second layer. Fiordalice at FIGs. 1-6, column 2, line 48 through column 4, line 50. Alternatively, after depositing the second layer of titanium nitride, a conductive plug of tungsten material is deposited or layered such that the opening is substantially filled. *Id.* at FIGs. 7-8 and column 4, lines 50 through 62. Portions of the tungsten material are removed to expose portions of the second layer of titanium nitride. *Id.* at column 4, lines 62 through 65.

Applicant submits that the presently claimed invention is not rendered obvious by the proposed combination of references because none of the references, alone or in combination teach or suggest all of the claim limitations. Claim 1 of the presently claimed invention recites, *inter alia*, “applying energy and pressure to the energy absorbing layer sufficient to cause the electrically conductive layer to fill the voids within the recess.” deSilva does not teach or suggest *applying* pressure to the energy absorbing layer, but rather describes a passive process of compressive stress. deSilva at column 3, lines 30 through 45. Mizobuchi also fails to teach or suggest applying any pressure to the energy absorbing layer, passive or applied. Fiordalice fails

to provide the missing limitation. Fiordalice fails to teach or suggest an energy absorbing layer, and therefore, necessarily fails to teach or suggest applying energy and pressure to the energy absorbing layer sufficient to cause the electrically conductive layer to fill the voids within the recess. Consequently, the combination of deSilva, Mizobuchi, and Fiordalice fails to teach or suggest all of the claim limitations.

Furthermore, the combination of deSilva, Mizobuchi, and Fiordalice fails to teach or suggest “removing portions of the energy absorbing layer and the electrically conductive layer that are situated above the top surface of the dielectric material” as recited in claim 1 of the presently claimed invention. As acknowledged by Examiner, “the combined teachings of deSilva and Mizobuchi fail to disclose removing portions of the energy absorbing layer and the electrically conductive layer that are situated above the top surface of the dielectric material.” Office Action of May 14, 2008, page 4. Therefore, Examiner relies on Fiordalice to provide the missing limitation.

The Examiner contends that it would be obvious to remove overlying layers above the dielectric layer of deSilva and Mizobuchi according to the teaching of Fiordalice because the steps are standard photolithographic patterning and etching steps in forming interconnect structures. Office Action of May 14, 2008, page 5. Applicant respectfully disagrees. As discussed above, Fiordalice does not teach or suggest an energy absorbing layer and consequently can not teach or suggest removing portions of the energy absorbing layer.

Additionally, although patterning and etching steps may be known in the art, the Examiner has not provided articulated reasoning with rational underpinning to support the assertion that a person of ordinary skill would utilize these processes as recited in claim 1 of the presently claimed invention. A person of ordinary skill would understand that patterning and etching steps are only performed at certain steps in a fabrication process, and for a particular reason. The examiner has not provided articulated reasoning why a person of ordinary skill would remove particular layers or even the particular portions of layers of either deSilva or Mizobuchi. Thus, the combination of deSilva, Mizobuchi, and Fiordalice cannot render claim 1 of the presently claimed invention obvious.

Moreover, no reason exists to combine the cited references as proposed. deSilva is directed to methods of removing voids in aluminum plugs. Fiordalice is directed to depositing a

conformal titanium nitride barrier lining separating an insulating layer and a metal plug. While Mizobuchi, is directed to a means for controlling a crystal orientation by controlling the surface roughness of a bottom film.

There is no articulated reasoning in deSilva, Mizobuchi, or Fiordalice that would have prompted one of ordinary skill in the art to use the seed layer of Mizobuchi in combination with the barrier layers of either deSilva or Fiordalice. In addition, the common knowledge or the nature of the problem does not provide a reason that would have prompted the combination.

Specifically, nowhere in Mizobuchi, Fiordalice or deSilva is there any articulated reasoning that would have prompted one of ordinary skill in the art to modify the structure of deSilva by adding a seed layer as described in Mizobuchi. deSilva does not teach or suggest a seed layer. Neither deSilva nor Fiordalice provides any articulated reasoning to change the first titanium nitride layer of Fiordalice to be a different material, such as tungsten.

Similarly, even assuming a motivation to include a seed layer in deSilva exists, which Applicant does not concede, no motivation exists to incorporate the tungsten seed layer of Mizobuchi into the deSilva device. Especially, given the teaching in Fiordalice that the seed layer and barrier layer are the same material. Fiordalice at column 2, lines 66 through 68. In addition, Mizobuchi teaches that tungsten is readily deposited directly onto a silicon surface and that an underlying layer is not required. Mizobuchi at column 3, lines 49 through 45. So, a person of ordinary skill in the art would not be motivated to combine the underlying barrier layer of deSilva or Fiordalice with the tungsten seed layer of Mizobuchi.

Furthermore, Mizobuchi teaches away from the proposed combination. Mizobuchi states that titanium nitride formation requires special treatment and equipment and that the use of titanium nitride is undesirable. *Id.* at column 1, line 62 through column 2, line 40; and column 3, lines 60 through 64. In Fiordalice, each of the barrier layer and the seed layer are formed from titanium nitride. Fiordalice at column 2, line 48 through column 4, line 50. deSilva also teaches the use of titanium nitride. deSilva at column 5, lines 2 through 7. Moreover, the method of deSilva relies upon the thermal expansion coefficient of titanium nitride to function as suggested. *Id.* The Examiner has not provided any articulated reasoning why a person of ordinary skill would be motivated to combine the seed layer of Mizobuchi in combination with the method of deSilva, which relies on thermal expansion coefficients of the layers. Consequently, there is no

reason that a person of ordinary skill would combine the teachings of Mizobuchi with the teachings of either deSilva or Fiordalice to produce the claimed invention.

Thus, the combination of deSilva, Mizobuchi, and Fiordalice does not render claim 1 obvious because the combination does not teach or suggest all of the presently claimed limitations and there is no reason to combine the references in the manner asserted. In light of the above, Applicant submits that independent claim 1 is allowable and, accordingly, requests withdrawal of the 35 U.S.C. 103(a) obviousness rejection.

The nonobviousness of independent claim 1 precludes a rejection of claims 2 through 4, 6, 9 through 14, and 64 which depend therefrom because a dependent claim is obvious only if the independent claim from which it depends is obvious. See In re Fine, 5 U.S.P.Q.2d 1596, 1600 (Fed. Cir. 1988), see also MPEP § 2143.03. Therefore, the Applicant requests that the Examiner withdraw the 35 U.S.C. § 103(a) obviousness rejection to independent claim 1 and claims 2 through 4, 6, 9 through 14, and 64 which depend therefrom.

Claim 14 is additionally allowable because the disclosed dimensions are critical and the disclosed method of manufacturing produces unexpected results. The Examiner acknowledges that the combination of deSilva, Mizobuchi, and Fiordalice fails to disclose a recess with an aspect ratio greater than about four to one. Office Action of May 14, 2008, page 6. The examiner contends that one of ordinary skill in the art would have been led to the recited dimensions through routine experimentation and optimization to obtain a desired contact opening. *Id.* Applicant respectfully disagrees.

The aspect ratio is critical because the step coverage of the conductive layer within the recess may depend upon the aspect ratio, and poor step coverage may result in electrical failure. As-filed specification at page 2, lines 20 through 24. In addition, the requisite flowability of the conductive layer is directly affected by the aspect ratio. As-filed specification at page 11, lines 11 through 20. Furthermore, as discussed in U.S. Patent 6,306,761 to Taguchi, a person of ordinary skill in the art would recognize the criticality of the aspect ratio because some techniques known in the art are limited to an aspect ratio less than about 2 to 3. Taguchi, column 1, line 26 through column 2, line 11; and column 8, lines 3 through 6.

Moreover, Fiordalice teaches that sputter deposited titanium nitride is not very conformal and its step coverage within high aspect ratio contacts is poor resulting in poor reliability.

Fiordalice at column 1, lines 19 through 27. Fiordalice also teaches that chemically vapor deposited titanium nitride may also be less than desirable for films of high aspect ratio. *Id.* at lines 37 through 40. However, the presently claimed method is able to achieve the unexpected result of desirable step coverage and filling a recess having an aspect ratio greater than 4 to 1. As-filed specification at page 13, lines 3 through 6. Therefore, claim 14 is additionally allowable because the disclosed aspect ratio is not an obvious optimization.

Obviousness Rejection Based on U.S. Patent No. 5,926,736 to deSilva in View of U.S. Patent No. 5,990,556 to Mizobuchi et al. and U.S. Patent No. 5,420,072 to Fiordalice et al., and Further in View of U.S. Patent No. 6,306,761 to Taguchi

Claim 5 stands rejected under 35 U.S.C. § 103(a) as being unpatentable over deSilva (U.S. Patent No. 5,926,736) in view of Mizobuchi et al. (U.S. Patent No. 5,990,556) and Fiordalice et al. (U.S. Patent No. 5,420,072), as applied to claims 1 through 4, 6, 9 through 14, and 64 above, and further in view of Taguchi (U.S. Patent No. 6,306,761). Applicant respectfully traverses this rejection, as hereinafter set forth.

The discussion of deSilva, Mizobuchi and Fiordalice, *supra*, is incorporated herein. The Examiner relies on Taguchi as teaching heating the diffusion barrier in an environment substantially containing a nitrogen gas. Office Action of May 14, 2008, page 7. However, claim 5 depends on claim 1 and, therefore, includes all of the limitations of claim 1. As such, claim 5 includes the limitations of “applying energy and pressure to the energy absorbing layer sufficient to cause the electrically conductive layer to fill the voids within the recess” and “removing portions of the energy absorbing layer and the electrically conductive layer that are situated above the top surface of the dielectric material.” The combination of deSilva, Mizobuchi, and Fiordalice does not teach or suggest these limitations for the reasons previously discussed. Moreover, Taguchi also fails to cure the deficiencies of deSilva, Mizobuchi and Fiordalice.

Therefore, claim 5 is allowable at least by virtue of its dependency from claim 1.

Claim 5 is additionally allowable because Taguchi does not cure the deficiencies of the combination of deSilva, Mizobuchi, and Fiordalice. Specifically, there is no motivation to combine the references as suggested, the claimed invention produces unexpected results, and the references teach away from the asserted combination. For substantially the same reasons

discussed above, there is no motivation to combine deSilva, Mizobuchi, and Fiordalice. In addition, there is no motivation to combine the teachings of Taguchi with either Fiordalice or Mizobuchi. Fiordalice is directed to a method of depositing conformal layers. Fiordalice at Abstract. Mizobuchi is directed to obtaining a preferred crystal orientation. Mizobuchi at abstract. By contrast, Taguchi is directed to a method of eliminating voids which includes removal of oxide layers as well as heating the device to cause the aluminum to reflow. Neither Fiordalice nor Mizobuchi contain any teaching or suggestion of removing voids by the reflow process described in Taguchi. The Examiner has not identified why one skilled in the art would be motivated to combine the two teachings.

Furthermore, Mizobuchi teaches away from the proposed combination. As presented herein, Mizobuchi states that the use of titanium nitride is undesirable. Mizobuchi at column 3, lines 60 through 64. However, Taguchi describes using a titanium nitride layer. Taguchi at Example 2. The Examiner has not provided any articulated reasoning why a person of ordinary skill would be motivated to combine the teachings of Taguchi with Mizobuchi.

Finally, claim 5 is not obvious in view of Taguchi since the presently claimed invention achieves unexpected results. Taguchi teaches that oxides formed on the surface of, and between, layers obstruct the thermal flow during the reflow process. Taguchi at column 4, lines 38 through 51. Additionally, Taguchi teaches that absent the step of removing these oxides voids remain despite a high pressure reflow process. *Id.* In contrast, the presently claimed method lacks the step of removing any oxide layers. However, the claimed method results in successful step coverage and filling a void having a high aspect ratio. (As-filed specification at page 13, lines 3 through 6.) Applicant respectfully requests the § 103(a) rejection of claim 5 be withdrawn.

Obviousness Rejection Based on U.S. Patent No. 5,926,736 to deSilva in View of U.S. Patent No. 5,990,556 to Mizobuchi et al. and U.S. Patent No. 5,420,072 to Fiordalice et al., and Further in View of U.S. Patent No. 5,869,395 to Yim

Claim 15 stands rejected under 35 U.S.C. § 103(a) as being unpatentable over deSilva (U.S. Patent No. 5,926,736) in view of Mizobuchi et al. (U.S. Patent No. 5,990,556) and Fiordalice et al. (U.S. Patent No. 5,420,072), as applied to claims 1 through 4, 6, 9 through 14,

and 64 above, and further in view of Yim (U.S. Patent No. 5,869,395). Applicant respectfully traverses this rejection, as hereinafter set forth.

The discussion of deSilva, Mizobuchi and Fiordalice, *supra*, is incorporated herein. The Examiner relies on Yim as teaching a recess having a contact hole situated below a trench, the contact hole terminating at an end thereof at the semiconductor substrate and terminating at an opposite end thereof at the trench, the trench extending from the opposite end of the contact hole to the top surface of the dielectric material, the trench extending parallel to the plane of the semiconductor substrate as recited in the presently claimed invention. Office Action of May 14, 2008, page 8. However, claim 15 depends on claim 1 and, therefore, includes all of the limitations of claim 1. As such, claim 15 includes the limitations of “applying energy and pressure to the energy absorbing layer sufficient to cause the electrically conductive layer to fill the voids within the recess” and “removing portions of the energy absorbing layer and the electrically conductive layer that are situated above the top surface of the dielectric material.” The combination of deSilva, Mizobuchi, and Fiordalice does not teach or suggest these limitations for the reasons previously discussed. Moreover, Yim also fails to teach or suggest these limitations. Therefore, claim 15 is allowable at least by virtue of its dependency from claim 1.

Obviousness Rejection Based on U.S. Patent No. 5,926,736 to deSilva in View of U.S. Patent No. 5,420,072 to Fiordalice et al.

Claims 65 and 66 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over deSilva (U.S. Patent No. 5,926,736) in view of Fiordalice et al. (U.S. Patent No. 5,420,072). Applicant respectfully traverses this rejection, as hereinafter set forth.

The teachings of deSilva and Fiordalice are enumerated above.

Applicant submits that the presently claimed invention is not rendered obvious by the proposed combination of references because the combination does not teach or suggest all of the claim limitations. In addition, no motivation exists to combine the cited references as proposed.

For substantially the same reasons as discussed above with respect to claim 1, the combination of deSilva and Fiordalice does not teach or suggest all of the claim limitations. The Examiner acknowledges that deSilva fails to teach or suggest “forming a seed layer on the

diffusion barrier layer over the top surface of the dielectric material and within the recess, the diffusion barrier layer comprising a material having a melting point greater than or equal to that of a material of the seed layer, wherein the material of the seed layer comprises tungsten,” or “removing portions of the energy absorbing layer and the electrically conductive layer that are situated above the top surface of the dielectric material” as recited in claim 65 of the presently claimed invention. Office Action of May 14, 2008, pages 9 and 10.

The Examiner contends it would be obvious to incorporate the seed layer of Fiordalice because it would result in improved electromigration resistance and improved deposition of a conductive layer over the seed layer. Office Action of May 14, 2008, page 11. However, Claim 65 of the presently claimed invention recites, *inter alia*, “forming a seed layer on the diffusion barrier layer over the top surface of the dielectric material and within the recess, the diffusion barrier layer *is different from* the material of the seed layer.” Fiordalice teaches that the two layers underlying the conductive layer are the same material and not that “the material of the diffusion barrier layer is different from the material of the seed layer” as recited in claim 65.

Further, Fiordalice does not teach or suggest an energy absorbing layer and therefore necessarily does not teach or suggest removing a portion of the energy absorbing layer. Although deSilva teaches an energy absorbing layer, it does not describe *removing* a portion. Moreover, the Examiner has not provided any articulated reasoning with rational underpinning why a person of ordinary skill would choose to remove portions of the particular layers recited in claim 65.

Additionally, there is no articulated reasoning that would have prompted a person of ordinary skill to combine deSilva and Fiordalice in the manner asserted. Fiordalice lacks any teaching or suggestion of removing voids by the process disclosed in deSilva. Thus, one skilled in the art would not be motivated to try to combine the teaching Fiordalice with deSilva. Further, nowhere in Fiordalice or deSilva is there any articulated reasoning that would have prompted one of ordinary skill in the art to modify the structure of deSilva by adding a seed layer. In addition, the common knowledge or the nature of the problem does not provide a reason that would have prompted the combination. Therefore, Applicant respectfully requests the §103 obviousness rejection to claim 65 be withdrawn.

Claim 66 is allowable because the combination of deSilva and Fiordalice does not teach or suggest all of the claim limitations and since there is no reason to combine the references as

asserted. For substantially the same reasons as discussed herein, neither deSilva nor Fiordalice, alone or in combination, teach or suggest the limitation “applying energy and pressure to the energy absorbing layer and the electrically conductive layer sufficient to cause the electrically conductive layer to fill the voids within the recess” as recited in the presently claimed invention. deSilva does not teach or suggest *applying* pressure to the energy absorbing layer, but rather describes a passive process of compressive stress. deSilva at column 3, lines 30 through 45. Additionally, Fiordalice does not teach or suggest an energy absorbing layer and therefore necessarily does not teach or suggest applying energy and pressure to the energy absorbing layer. Moreover, there is no motivation to combine the references as suggested. As discussed above, there is no articulated reasoning to modify the structure of deSilva by adding a seed layer.

In light of the above, Applicant submits that independent claims 65 and 66 are allowable and, accordingly, requests withdrawal of the 35 U.S.C. 103(a) obviousness rejection.

ENTRY OF AMENDMENTS

The amendments to claims 1, 64 and 66 above should be entered by the Examiner because the amendments are supported by the as-filed specification and do not add any new matter to the application.

CONCLUSION

Claims 1 through 6, 9 through 15, and 64 through 66 are believed to be in condition for allowance, and an early notice thereof is respectfully solicited. Should the Examiner determine that additional issues remain which might be resolved by a telephone conference, the Examiner is respectfully invited to contact Applicant's undersigned attorney.

Respectfully submitted,



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